Ultrasound Guidelines Council
Field Technician Study Guide
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Chapter III – Ultrasound and the Beef Carcass
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Purpose
The purpose of this chapter is to introduce the primary value indicators of the beef carcass and to explain how ultrasound is used to measure these indicators in live animals.

Anatomy
Figure 1 is a cross-sectional image taken between the 12 and 13th ribs to illustrate important beef cattle anatomical structures and reference points. The image is characterized by the inclusion of four primary muscles- longissimus dorsi (ribeye or loin muscle; REA or LMA), spinalis dorsi, longissiumus costarum, and the intercostals. The spine is located on the medial side of the longissimus dorsi, and the subcutaneous fat layer is located immediately above (dorsal) the longissimus dorsi. A structure unique to the bovine is the presence of acorn fat found towards the medial end on the dorsal portion of the longissimus dorsi. While some variation exists in the clarity of these anatomical structures based on animal age, size, breed, and primarily level of fatness; the presence and relative size of the primary muscle groups change significantly as an image is taken more anterior or posterior to the proper 12-13th rib position. Figure 2 is a cross-sectional image taken at the 11-12th ribs. Note the pronounced increase in size of the spinalis dorsi. The spinalis becomes even larger relative to the longissimus as you move forward on the animal. Conversely, Figure 3 is a cross sectional image taken at the juncture of the 13th rib and 1st lumbar vertebrae. In this image the spinalis dorsi is no longer present, and the shape of the longissimus tends to have less depth as you move to the loin region of the animal (lumbar vertebrae). An excellent resource tool for understanding beef carcass anatomy is the Bovine Myology & Muscle Profiling website found at http://bovine.unl.edu/ .

USDA Yield and Quality Grading
USDA beef Yield and Quality Grades are applied voluntarily in processing plants by trained USDA personnel, and serve as the basis under which beef is priced and traded. Yield Grades are an estimate of yield of boneless, closely trimmed retail cuts from the round, loin, rib, and chuck and are expressed numerically from 1 to 5 with lower numerical YG associated with superior cutability and higher percentage of retail cuts (YG 1 ~ 53.5% retail cuts, YG 2 ~ 51.2%, YG 3 ~ 48.9, YG 4 ~ 46.6%, YG 5 ~ 44.3%). Factors influencing YG include 1) external fat thickness, 2) hot carcass weight, 3) ribeye area, and 4) percentage kidney, pelvic, and heart fat. USDA Yield Grade may be determined with the following formula:

$$YG = 2.5 + (2.5 \text{ x fat thickness, in}) + (.20 \text{ x } \%KPH) - (.32 \text{ x ribeye area, in}^2) + (.0038 \text{ x hot carcass weight, lb}).$$

USDA Quality Grades are an indicator of palatability and are the primary value determinant in beef carcass pricing. Quality Grades determined by two factors: marbling and maturity. Maturity of the carcass is estimated through visual observation of cartilage ossification of the thoracic vertebrae, after the carcass is split in the cooler, as well as color of the lean (muscle) tissue. Maturity is classified from A to E, which corresponds with increasing chronological age. Marbling is the small flecks of fat that are found distributed throughout the ribeye muscle (longissimus). The quantity of marbling is classified into Marbling Score Units ranging from Abundant (most marbling) to Practically Devoid (very little marbling). Maturity and marbling score are combined to arrive at a final USDA Quality Grade as shown in Figure 4. Within the young fed-cattle population (A maturity), marbling is the major determinant of QG. While marbling scores using in Quality Grading are assessed subjectively by a USDA grader, the quantity of marbling within the ribeye muscle can be determined objectively through chemical analysis and is generally reported as percent intramuscular fat. Ultrasound marbling technology allows for the estimation of percent intramuscular fat. Research studies have found a relatively high correlation of 0.75 between ultrasound-predicted percent fat in the live animal and the actual percent fat in the carcass ribeye (Wilson et al., 1998). We would not expect this relationship to be perfect, as marbling scores are subjective and influenced by a USDA grader's assessment of texture and distribution of intramuscular fat as well as color of the lean. Table 1 shows the relationship between intramuscular fat, marbling score, and quality grade.

Phenotypic Relationships between Carcass Traits and Ultrasound

Ultrasound has been used for over 35 years to determine body composition in live animals (Stouffer et al., 1959). Over time, technological advancements have improved ultrasound equipment and currently machines which allow for the entire longissimus muscle to be imaged with a long transducer are the instruments of choice (Duello, 1993; Herring et al., 1994). The accuracy of ultrasound measurements of carcass traits has been investigated for many years. The results indicate a great deal of variability that may be attributed to several sources including type of machine and expertise of the technician. Additionally, several statistics have been used to describe the accuracy of ultrasound in measuring carcass traits. The most commonly used statistic in the literature to describe accuracy data is the correlation coefficient. Duello (1993) summarized correlations between ultrasound and carcass measures of fat thickness and longissimus muscle area across studies using various machines. Correlations between ultrasonic and carcass measurements of fat thickness ranged from .75 to .96, and from .20 to .90 for longissimus muscle area. The average correlations were .86 and .73 for fat thickness and longissimus muscle area, respectively. Although correlations are useful in describing the relationship between ultrasound and carcass measures, they also have their limitations including: 1) population variation influences correlation coefficients (a larger than normal variation will produce high correlations, whereas a uniform population will result in lower correlations); 2) correlation coefficients do not reflect bias (consistent over or under-estimation of carcass measurement using ultrasound); and 3) correlation coefficients are not easily understood by producer groups (Houghton and Turlington, 1992). Due to these limitations, alternative methods of describing accuracy have been used. One method is to report the data in the form a frequency distribution (proportion of ultrasound measurements within a specific range of the carcass measurement). Mean difference (bias), absolute mean difference, and mean difference between ultrasound and carcass measures expressed as a percentage of the carcass measure have also been used. Another method of assessing accuracy in the standard error of prediction, which is thought to be the primary measure of the ability to correctly rank or predict differences between animals (Robinson et al., 1992).

Several factors have been investigated as potential causes of differences between ultrasound and carcass measures. Turlington (1990) reported that carcass position during chilling influences carcass measurements, and therefore influences the perceived accuracy of ultrasound. Additionally, carcass measurements are not taken without error. Robinson et al. (1992) reported a difference between carcass longissimus muscle area tracers, and attributed this difference to the tendency of tracers to deviate either to the inside or outside of the muscle boundary. The same study found average correlations were highest between scan data and the mean of the left and right sides of the carcass, rather than the particular side scanned; suggesting that much of the variation between sides of the carcass is due to handling and dressing procedures rather than biological differences. Similarly, Smith et al. (1992) compared measuring carcass longissimus muscle area with a dot grid versus an acetate tracing analyzed on an electronic digitizing board and found the two measurement procedures to have a correlation of .89.

The majority of the variation in ultrasound accuracy has been attributed to differences in technician proficiency. Consequently, the industry has developed certification standards to measure technician accuracy, and breed associations utilize technicians that have been accredited for compilation of ultrasound data for use in genetic evaluations. Results from these annual proficiency testing programs as well as published research papers confirm ultrasound is an accurate predictor of carcass traits. Typically, correlations between ultrasound estimates and actual carcass measures are >.85, >.80, and >.80 for fat thickness, ribeye area, and intramuscular fat, respectively. Furthermore, standard errors of prediction indicate that 67% of the time technicians tend to be within .07 in. fat thickness., 1.0 sq. in. ribeye area, and 1.0 % intramuscular fat of the actual carcass measure. The magnitude and direction of the difference between ultrasound and carcass measures (bias) may be affected by the level of fat thickness or size of the longissimus muscle. Several studies have reported ultrasound overestimates fat thickness and longissimus muscle area in leaner and lighter-muscled cattle and underestimates these traits in fatter and heavier-muscled cattle (Robinson et al., 1992; Duello, 1993; Herring et al., 1994; Greiner et al., 2003).

It is important to note that individual carcass trait measurements are only indicators of total carcass composition, and ultrasound serves as a mechanism by which we can predict these predictors. Therefore, the ability of ultrasonic measurements to predict retail product yield relative to carcass measurements is important if ultrasound is going to be used as a means to improve end product. Due to the expense involved in collecting carcass cut-out data, relatively few studies have examined the efficacy of using ultrasound/live animal measures to predict beef carcass retail yield. Studies have shown that prediction of retail yield is only slightly less effective using ultrasound measures of fat thickness and ribeye area compared to actual carcass measures (Herring et al., 1994; Williams et al., 1997; Greiner et al., 2003). Studies utilizing additional measures of rump fat depth and/or rump muscle area have shown ultrasound measures in the live animal were potentially more accurate predictors of retail product than measures collected on the carcass (Tait et al., 2003).

Collectively, the literature suggests that accurate estimation of carcass traits is attainable through the use of real-time ultrasound. In general, measurements of fat thickness are more closely associated with the carcass measures than are estimates of muscle area and intramuscular fat. Experienced, well-trained technicians can measure fat depths nearly as accurately as on the carcass, and longissimus muscle area only marginally less accurately than it can be measured on the carcass.

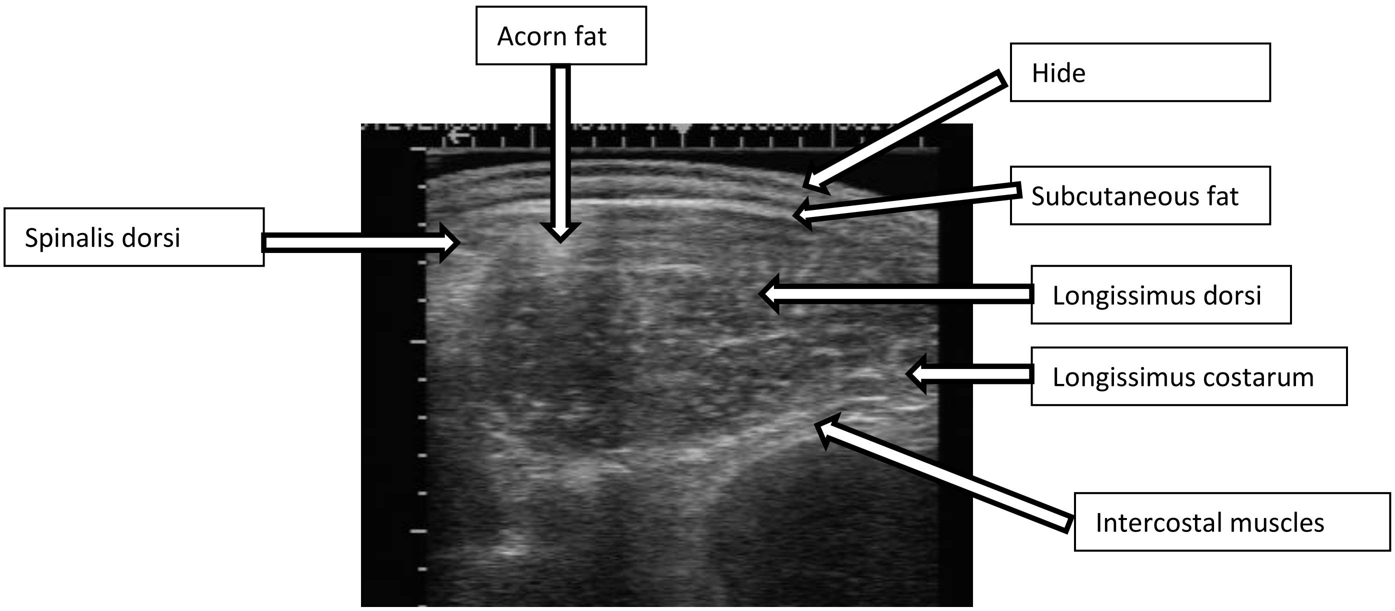

Figure 1. Cross-sectional ultrasound image collected at 12-13th ribs.

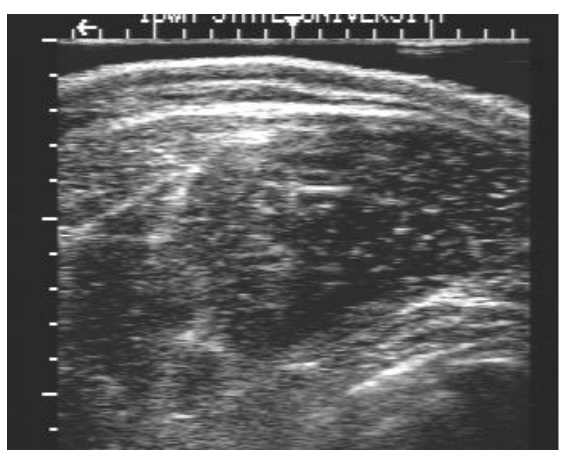

Figure 2. Cross-sectional ultrasound image collected at 11-12th ribs.

Figure 3. Cross- sectional ultrasound image collected at 13th rib- 1st lumbar vertebrae.

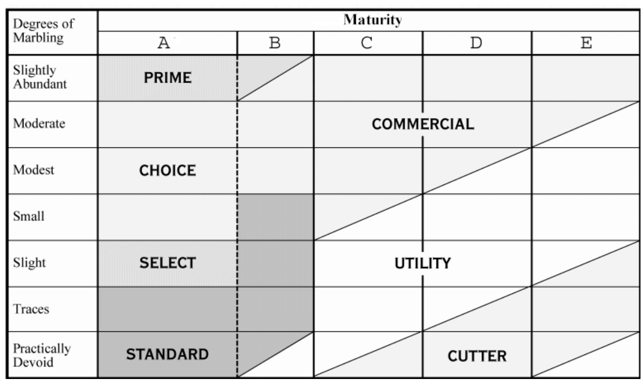

Figure 4. Relationship between carcass marbling score, maturity, and USDA Quality Grade.

Table 1. Relationship Between Chemical % Intramuscular Fat and USDA Quality Grades

% Intramuscular Fat	Degree of Marbling	USDA QG
< 2.30	Practically Devoid Traces	Standard
2.30-3.00 3.10-3.99	Slight	Select- Select+
4.00-5.79 5.80-7.69 7.70-9.89	Small Modest Moderate	Choice- $Choice^0$ Choice+
9.90-12.10 >12.10	Sl. Abundant Mod. Abundant	Prime

Wilson et al., 1998

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